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IMPROVING SRTM ELEVATION MODEL USING NDVI WITH ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

Digital elevation model (DEM) plays a substantial role in hydrological study, from understanding the hydrological characteristics of a watershed to set up a hydrological model, shall it include rainfall runoff or hydrodynamics simulation. Depending on the study nature and its objectives, high resolution DEM is often essential to set up a reliable hydrological model, and yet access to such is often a luxury. Obtained through radar based remote sensing, SRTM is a publicly available DEM with resolution of 92m outside US, and an essential dataset where no survey DEM is available [3]. This paper presents the study on improving SRTM dataset, using Normalized Difference Vegetation Index (NDVI), derived from Landsat with resolution of 30m, and Artificial Neural Networks. The assessment of the improvement and the applicability of this method in hydrology would be highlighted and discussed.

INTRODUCTION

Often in hydrological study, mainly in the process of setting up numerical model, DEM is a basis of understanding the hydrological characteristics of a water catchment and deriving inputs and numerous types of parameters required by the model. For example, time of concentration, slope, catchment size, and flow path length as parameters used in many empirical models can be derived from DEM. In addition, DEM can also be used as a direct input to a grid based model where spatial distribution of the hydrology is being considered as well, e.g. MIKE SHE, MIKE FLOOD, HEC-HMS (MOD-CLARK Model), etc.

Obtained through radar based remote sensing, SRTM is a publicly available DEM with resolution of ~92m outside US. It is an essential dataset for hydrological study where no survey DEM is available. However, apart from the coarse resolution, SRTM suffers from inaccuracy especially on area covered by canopy due to the 5.6 cm wavelength used which does not penetrate vegetation well [3]. Therefore, improvement to SRTM for the application in Hydrology is of a worthy research. This would significantly add value to public data, and allow more reliable hydrological models and study with budget and data constraints to be made available.

METHODOLOGY

The study area presented is a water catchment in a highly forested area in Singapore. Raw SRTM is then being compared with the available survey DEM with 30m resolution as the reference. For comparison standard, SRTM is then being resampled to 30m, and the difference between the two dataset (SRTM - DEM_{survey}) is defined as error. The absolute error distribution of the

The Normalized Difference Vegetation Index (NDVI) is a numerical indicator that utilizes the visible and near-infrared bands of the electromagnetic spectrum, to assess whether the target being observed contains live green vegetation or not. In other words, the higher the canopy density of a certain area/ grid, the higher is its NDVI. The NDVI algorithm subtracts the red reflectance values from the near-infrared and divides it by the sum of near-infrared (NIR) and red bands (RED) (see equation 1) [1].

$$NDVI = (NIR - RED) / (NIR + RED) \quad (1)$$

NDVI derived from LANDSAT 7 is found to be moderately correlated to the errors of SRTM, relative to the elevation range. This is logically expected as inaccuracy suffered in SRTM is partly due to radar limitation to penetrate the canopy [3]. This NDVI bands are then used as input of reference to train SRTM dataset with Survey DEM being the target dataset.

The data subset for training, validation and testing of the ANN can be seen in the figure 1 below.

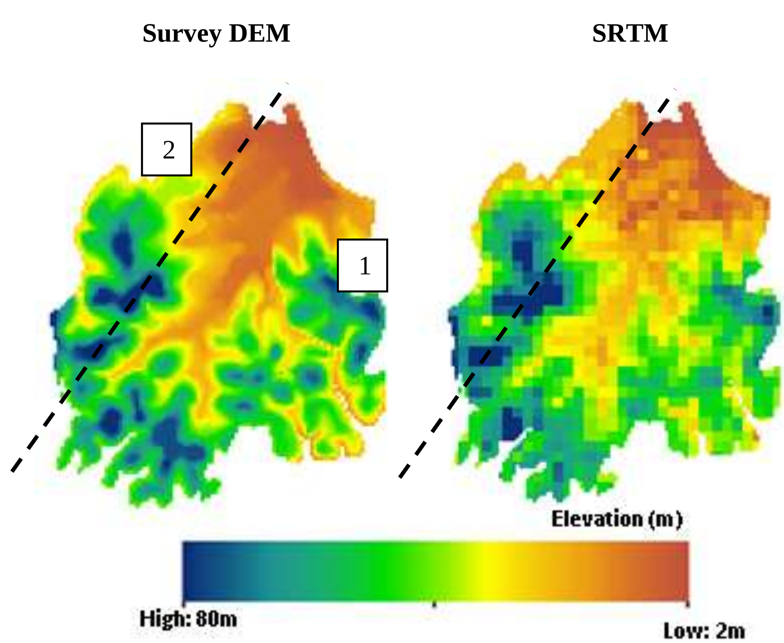

Figure 1 Survey (Reference) and SRTM DEM of study area with 30m grid size: (1) ANN Training and validation subset (90 & 10%) and (2) Testing subset

Since the improvements of SRTM intended in this study is for the application of hydrological study, especially as input for numerical models, the following criteria will be assessed: elevation, slope, delineated catchment and drainage line in reference to those derived from the surveyed DEM. In addition, several hydrological models ranging from lumped and empirical to distributed and conceptual will also be used to assess the applicability (e.g.. flood, water balance, drought, etc) and reliability of the improved SRTM. Root mean square error (RMSE), correlation coefficient (CC), and Nash–Sutcliffe model efficiency coefficient will be used as the assessment index for the comparison.

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